Effect of Critical Ice Shapes on Finite Wing Geometries

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Abstract

Aircraft certification requires the evaluation of the effects of critical ice accretions on aircraft aerodynamic components such as wings, tails and control surfaces. Ice accumulation on aerodynamic surfaces can have a significant impact on aircraft performance, handling qualities and thus aircraft safety. A wide range of ice accretions is possible depending on aircraft configuration, icing and flow conditions. Potential ice accretions include glaze ice, rime ice, runback and beak ice, as well as small ice shapes which can cause considerable degradation in aircraft performance. In general, the extent of flow separation caused by ice accumulation on the aerodynamic surfaces is a function of the ice shape and wing geometry. The term "critical ice shape" is often used to identify ice shapes responsible for large degradation in the aerodynamic performance of lifting surfaces. The ìcriticalityî of possible ice accretions is not well understood, and information is needed for guidance in complying with requirements established in the FAA In-flight Aircraft Icing Plan Task 12.

Recently, the Federal Aviation Administration (FAA), the National Aeronautics and Space Administration (NASA) and several general aviation aircraft manufactures have expressed a strong interest in comprehensive research plans for a systematic evaluation of critical ice accretion effects on finite wings. The main requirement is the development of a three-dimensional experimental database of ice accretion effects on aircraft aerodynamic surfaces for developing certification guidance material, and for developing and validating simulation tools for aerodynamic analysis and design.

The critical ice accretion program is a two-year systematic research effort which will address the effects of a range of ice shapes on the aerodynamic performance and handling qualities of a finite wing. Specific goals of this program include:

- Investigate wing sensitivity to various forms of ice accretions.
- Determine the effect of glaze ice shape features such as horn angle, horn location, horn height and surface roughness on wing aerodynamic performance.
- Develop an experimental database of ice accretion effects on the aerodynamic performance of a finite span general aviation swept wing with a simple aileron control surface.

Extensive wind tunnel tests were conducted with a general aviation swept and tapered finite wing with an aileron control surface and with a range of ice shapes. Ice shapes tested included ice shape castings developed from icing tunnel tests and simulated LEWICE ice shapes. Aerodynamic force and moment coefficients, pressure and hinge moment coefficients were obtained for a range of angles of attack. Limited flow simulation studies were performed with a 3D Navier-Stokes equations to support the experimental investigation and to explore the ability of state-of-the-art CFD codes in predicting iced wing performance degradation due to ice accretions.

The research findings will be compiled in a final report which will be submitted to the FAA at the end of this two-year research program.